Economic value of pharmacy-led medicines reconciliation at admission to hospital: an observational, UK-based study

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ABSTRACT

Objective To describe the cost–benefits of pharmacy-led medicines reconciliation (MR) on admission by applying a theoretical model (University of Sheffield School of Health and Related Research—SCHARR model) to real-world data.

Methods This was a retrospective, single-centre study.

Setting 1000-bedded teaching hospital in London, UK. Clinical pharmacy contributions related to unintended medication discrepancies (averted preventable adverse drug events, pADEs), documented by pharmacy staff on prearranged days during 2012, were assessed for clinical significance by a panel of senior clinical pharmacists using the SCHARR model. Costs avoided were allocated according to the SCHARR model. Pharmacy staff carrying out admission MR were timed. Net cost avoidance was calculated by subtracting cost of time taken to carry out MR from the costs avoided by averting pADEs. Sensitivity analyses were carried out.

Results 118 pADEs averted as a result of MR were recorded over the 6 reporting days. 116 were rated for clinical significance. Gross costs avoided were £36 135–£75 249 (€44 446–€92 556). The admission MR process was timed for 48 patients. The mean time to complete MR for one patient was 14 min (range 1–40 min). The cost of carrying out one MR, based on the cost of employing a first-level post-foundation clinical pharmacist was £7.56 (€9.30). The net benefit of one MR was £34–£80 (€42–€98). The benefit:cost ratio was 5.53:1–11.51:1.

Conclusions Pharmacy-led MR on admission has significant economic, as well as clinical benefits. Further work is required for full economic evaluations of MR.

INTRODUCTION

Medication discrepancies and errors often occur during transitions of care and are known to account for a significant proportion of potential and actual adverse drug events (ADEs).[1–4] Prescribing errors on admission to hospital are high[5] and if uncorrected can lead to significant morbidity.[6] Medicines reconciliation (MR), a process for identifying and correcting unintended medication discrepancies as patients move between care settings is an internationally endorsed and recommended safety strategy.[7–9] In the UK, the National Institute for Health and Care Excellence (NICE) has described the aim of MR on admission as 'to ensure that medicines prescribed on admission correspond to those that the patient was taking before admission.'[9]

Most studies have focused on reductions in unintended medication discrepancies as an outcome of MR;[4 10] however, there is evidence that MR can reduce preventable adverse drug events (pADEs)[11] and posthospital healthcare utilisation.[12]

The involvement of pharmacists in MR on admission is well documented in the literature.[4 13–15] Bond *et al*[16] evidenced a link between clinical pharmacy-led medication history-taking on admission and lower hospital mortality rates. A study of the Swedish Lund Integrated Medicines Management Model[17] found that 36% of clinical pharmacists' recommendations related to admission medication reconciliation. Ninety-two per cent of the pharmacists' recommendations were judged to have some clinical significance, and 10% were very significant. Other researchers have found process benefits.[13 18 19]

MR is a complex and resource-intensive activity.[20–23] This may be a barrier to implementation.[21 23] Pevnick *et al*[23] in their article on the problem with MR describe the high cost of pharmacist interventions, the lack of clear cost–benefit data of MR and the resulting reluctance of institutions to invest in pharmacy staff to lead MR programmes. However, few studies have looked at costs and resource use of MR at hospital admission. A study from the Netherlands compared the labour costs of hospital pharmacy staff preventing errors through MR with medication costs after discharge.[24] At 6 months postdischarge, the savings in medication costs outweighed staff costs. A systematic review of effects and costs of pharmacy-led MR[22] could not come to a definite conclusion on the effects and costs. Both studies combined admission and discharge MR.

In the UK, the case for the cost-effectiveness of pharmacist-led MR at admission was based on economic modelling work by Karnon and colleagues, researchers at the School of Health and Related Research (SCHARR), University of Sheffield, UK.[14 25] Literature-based values of the costs of medication errors were compared with the modelled benefits of different MR interventions or systems to determine the most cost-effective system for avoiding pADEs. The output was the economic model which led to NICE adopting pharmacy-led admission MR as the most cost-effective and clinically effective model of performing MR in the UK National Health Service.[9] Table 1 shows the modelled costs of pADEs. For pharmacy-led MR, Campbell *et al*[14] allocated a cost of £10.28 (95% CI 5.58 to 21.39) or €15.00 per inpatient admission. To the best of our knowledge, there are no

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Table 1 Modelled costs of preventable adverse drug events (pADEs)

Event	2007 Cost
Minor, no harm medication errors*	£0–£6
Significant pADEs (non-increased length of stay)	£65–£150
Serious pADEs	£713–£1484
Severe, life-threatening or fatal pADEs	£1085–£2120

*Amended from Karnon *et al*[25] previously 'detected medication errors'.

published studies demonstrating the application of this theoretical model to observed practice.

The aim of this study was to apply the SCHARR costing model[25] to real-world pharmacy-led MR on admission data in order to assess the costs and impacts of this service. The objectives were to:

- cost the time taken by clinical pharmacy staff to perform MR on admission
- identify the potential clinical significance and associated cost avoidance of pADEs averted by MR, according to the SCHARR scale and data
- calculate the costs avoided or incurred by undertaking MR.

METHODS

Setting

King's College Hospital is a 1000-bedded London teaching hospital that provides secondary healthcare services to the local population and accepts national and international referrals for tertiary care specialist services, including liver disease and transplantation, neurosciences, haemato-oncology and fetal medicine.

The Pharmacy Department supplies all medicines used in the hospital, with the exception of medicines that patients bring from home; pharmacy staff assess all home medicines to ensure they are suitable for use while in hospital and to aid in MR, a key role for pharmacy staff. Clinical pharmacists and pharmacy technicians are part of the ward multidisciplinary teams and spend most of their time on the wards providing direct clinical pharmacy services. The pharmacy technician role mainly consists of conducting and documenting medication histories and identifying obvious discrepancies. Pharmacists complete all steps of the MR process. They also review medication orders and advise or intervene as necessary to optimise medication, ensure appropriateness and prevent medication errors. At the time of the study, Electronic Prescribing and Medicines Administration (EPMA) was being rolled out across wards, but was not fully implemented.

The clinical pharmacy service runs an activity and quality monitoring programme.[15] Pharmacy staff record the number of MRs completed daily, and at regular intervals, they also document all their clinical contributions to care, including unintentional MR discrepancies which have been identified and resolved, on an in-house designed template. The documentation of clinical pharmacy contributions takes place on a single day once a month, with pharmacy staff allocated to half the hospital wards participating every other month. This equates to 6 full days of recorded contributions every 12 months. Consecutive days of the week (Monday to Friday) are selected to be the day on which contributions are recorded. Contributions are analysed by type, acceptance, subsequent corrective actions and potential clinical significance.

Clinical significance rating of pADEs

All clinical contributions related to unintentional discrepancies detected by pharmacy staff conducting MR on admission and documented during the calendar year 2012 were collated. A panel of five practising senior clinical pharmacists was convened to assess the clinical significance of the unintentional discrepancies, hereafter called averted pADEs. The panel was asked to assume that all the unintentional discrepancies would have led to a pADE and to decide on the most likely level of clinical significance if the pADE was not averted, using the SCHARR rating scale (table 1). The panel meetings were organised and facilitated by an experienced clinical pharmacy technician (SQ). Consensus was defined as agreement between four out of five (80%) panel members. If consensus was not reached or the panel required more information for a decision to be made, an adjudicating senior clinical pharmacist (RO) made a final decision.

Costing the time taken to complete MR activities

Over a 2-week period, two pharmacy undergraduate students observed and timed six pharmacists and five pharmacy technicians of varying grades carrying out MR activities during standard working hours (Monday to Friday, 9:00–17:30). Staff and patients were selected according to availability.

- Stage 1—Compiling and documenting a medication history
- Stage 2—Comparing the medication history with inpatient medication orders to identify unintentional discrepancies
- Stage 3—Resolving discrepancies

Stages 2 and 3 were combined as they were usually carried out by the same person (the pharmacist). The clinical or demographic characteristics of the patients were not recorded.

The cost of staff time to carry out MR was calculated from the observations and calculated on the mid-point of the 2012 salary range for a first-level post-foundation clinical pharmacist (UK National Health Service Band 7), offset by 80% capacity.[26] This pharmacist grade was used as this is the staff type who will most commonly undertake all steps of the process. Employer on-costs were included.

The Consolidated Health Economic Evaluation Reporting Standards (CHEERS) checklist[27] was used as a guide for calculating the economic impact. The study was carried out from a health system perspective only. The population was patients admitted to the hospital, requiring MR. The time horizon was the year 2012. The economic impact was taken as the difference between inputs or costs incurred (average cost of staff time to complete MR) and costs avoided (cost avoidance value of pADEs averted due to MR). Sensitivity analyses were carried out by substituting different grades of staff and varying the staff time required to carry out MR. Realistic alternative scenarios were chosen to test the limits of the economic impacts. All costs were updated to 2012. Karnon *et al*'s costs[25] were revalued to reflect cost avoidance in 2012 by adjusting to the Retail Price Index, using the following formula: sum of money multiplied by (2012 index=242.7/2007 index=206.6).[28] The measures of benefits were pADEs averted and associated potential cost impact (costs avoided minus costs incurred).

RESULTS

In 2012, an average of 144 MRs was completed every weekday. One hundred and eighteen pADEs averted as a result of MR were recorded over the 12 half-hospital days (6 full days) of reporting. Every weekday was covered at least once. Thirteen per cent of newly admitted patients had a pADE averted by

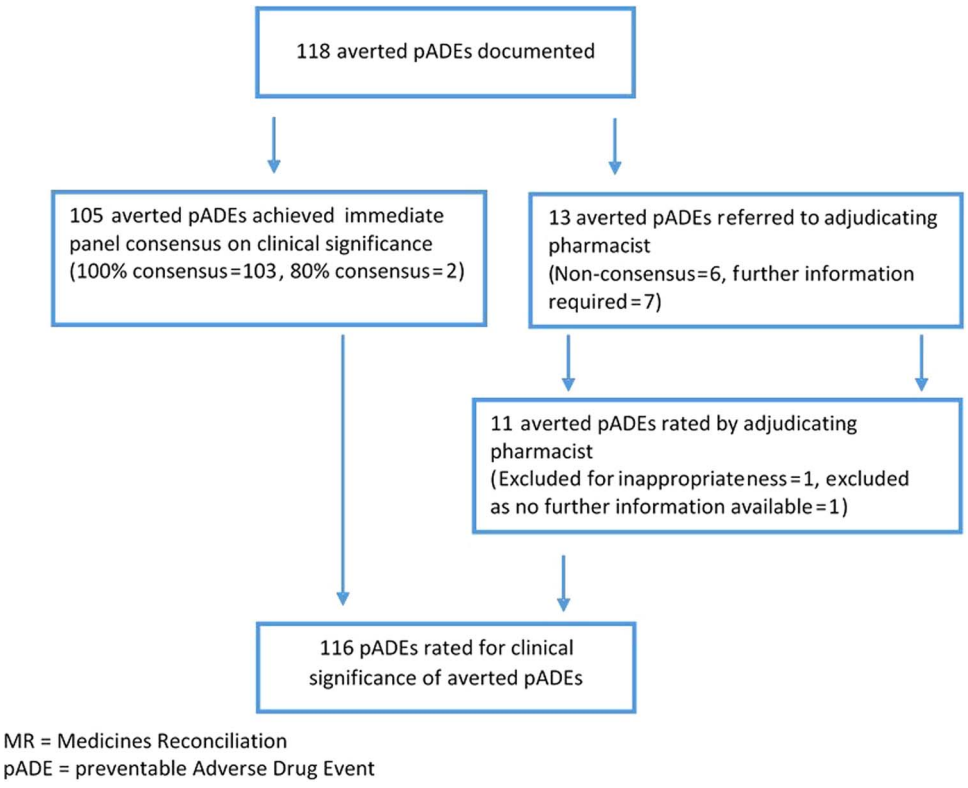

Figure 1 Flow chart of pharmacy panel and averted preventable adverse drug events (pADEs).

Table 2 Patient characteristics

	Paediatric patients (n=7)	Adult patients (n=109)
Mean age (SD)	**7 years (5.8)**	**67 years (18.6)**
Admitting clinical specialty (%)	General Paediatrics 5/7 (71%) Paediatric Neurosurgery 2/7 (29%)	Acute medicine, 47 (43%) Surgery, 15 (14%) Cardiology, 11 (10%) Neurosurgery, 8 (7%) Haematology, 7 (6%) Healthcare of the ageing, 7 (6%) Neurology, 6 (6%) Liver, 4 (4%) Gynaecology, 3 (3%) Renal, 1 (1%)

Table 3 Potential clinical significance of pADEs averted due to MR and associated cost avoidance (2012 values)

	Number of contributions	Total minimum cost avoidance £/euro	Total maximum cost avoidance £/euro
Minor/no harm	36	£0/€0	£253/€312
Significant	44	£3360/ €4133	£7753/ €9536
Serious	30	£25 128/ €30 907	£52 299/ €64 328
Severe, life-threatening or fatal	6	£7648/ €9407	£14 943/ €18 380
Total	116	£36 135/ €44 446	£75 249/ €92 556

MR, medicines reconciliation; pADEs,preventable adverse drug events.

MR. Ninety-eight per cent (116/118) of the averted pADEs were rated for clinical significance (figure 1). Of the 116 patients whose averted pADEs were given a clinical significance rating, seven were children, aged 16 years or under. Table 2 shows basic patient characteristics. Table 3 summarises the assigned clinical significance and associated cost avoidance.

The cost avoidance of the averted pADEs due to admission MR on the 6 full recording days was calculated to have a minimum 2012 value of £36 135 (€44 446) and a maximum value of £75 249 (€92 556) (figure 2).

MR for 48 patients was observed. Stages 1, 2 and 3 were timed for 42 patients, while for an additional 6 patients only the time taken to resolve discrepancies (Stage 3) was timed. The mean time taken to complete a drug history was 6.2 (SD 6.4) min, to identify and resolve discrepancies was 7.8 (SD 7.9) min and the total time to complete MR was 14 (95% CI 10.99 to 17.01) min. The minimum length of time taken was 1 min and the maximum was 40 min.

Costs incurred/inputs (based on mean times)

The total cost of employing a first-level post-foundation clinical pharmacist (National Health Service Band 7) working 37.5 hours a week was £51 000 (€62 730) annually. At 80% capacity, the number of available minutes in a 7.5 hour working day is 360 min. Based on 261 working weekdays in a year, the cost per minute of a pharmacist was £0.54 (€0.66). With a mean time of 14 min per MR, the cost of one MR was £7.56 (€9.30). A total of 864 MRs were carried out over 6 days at a staff cost of £6531 (€8034).

Figure 2 Details of the six potentially severe, life-threatening or fatal errors. CVA, cardiovascular accident.

Benefits

Table 4 has full details. The net benefit of conducting 6 days' worth of MRs (864 MRs) was calculated to be £29 604–£68 718 (€36 412–€84 522). The net benefit of one MR was therefore £34–£80 (€42–€98). The benefit:cost ratio was 5.53:1–11.51:1.

Sensitivity analyses

Table 4 details the results of the sensitivity analyses. Greatest net benefits were seen when a staff member on National Health Service Band 5 (eg, a senior pharmacy technician) conducted MRs, assuming each still took a mean of 14 min to perform. In all scenarios, benefits significantly exceeded costs except where all potential pADEs were of minimal clinical significance or MR always took the maximum 40 min to perform.

Comparison with literature

Observed cost=£7.56 (95% CI £5.93 to £9.18) per admission MR performed.

Campbell *et al*=£10.28 (95% CI 5.58 to 21.39) per inpatient admission.[14]

DISCUSSION

Despite the adoption of the SCHARR costing model within the National Health Service to justify the benefits of MR, no other published studies have applied the model to real-life data. Hammad *et al*,[22] in their systematic review of studies of 'complete MR' (on admission and through to discharge) also found scant published evidence of the cost-effectiveness of pharmacy-led MR.

In this study, 31% of averted pADEs were considered to be potentially severe or serious. The cost avoidance figures for just 6 days of MR activities were calculated to be between £29 604 and £68 718 (€36 412–€84 522). The extrapolated full year cost avoidance is significant and demonstrates the economic value of this activity. We have demonstrated that applying literature-derived figures to in-house MR data has demonstrated cost avoidance. However, large benefit:cost ratios are not robust to extreme inputs of minimal clinical significance of all averted pADEs or incurring maximum costs by taking a long time to undertake MR. As such, organisations with MR programmes should ensure that they have efficient MR processes and prioritise patients who will derive maximum clinical benefit.

This study has limitations. The rating panel consisted only of pharmacists. Different healthcare professions may have reached

Table 4 Full calculations and sensitivity analyses

Scenario	A. Gross benefits—Gross costs avoided by conducting 6 days' worth of MRs (864 MRs, 116 potential pADEs averted)	B. 2012 Annual staff cost	C. 2012 Staff cost per minute at 80% capacity	D. Mean cost of one MR (Column C×time taken to complete MR)	E. Cost of conducting 864 MRs (Column D×864)	F. Net benefits—net costs avoided by conducting 864 MRs (Column A–Column E)	Benefit:cost ratio (Column A/Column E)
Reference case: first-level post-foundation clinical pharmacist (National Health Service Band 7) conducts MR. Fourteen minutes taken to conduct each MR	**£36 135–£75 249 (€44 446–€92 556)**	**£51 000 (€62 730)**	**£0.54 (€0.66)**	**£7.56 (€9.30)**	**£6531 (€8034)**	**A. £29 604–£68 718 (€36 412–€84 522)**	**B. 5.53:1–11.51:1**
Senior pharmacy technician (National Health Service Band 5) conducts MR instead of first-level post-foundation clinical pharmacist. Fourteen minutes taken to conduct each MR	£36 135–£75 249 (€44 446–€92 556)	£35 000 (€43 050)	£0.37 (€0.45)	£4.32 (€5.28)	£3732 (€4591)	C. £31 659–£71 517 (€38 940–€87 964)	D. 9.68:1–20.16:1
Consultant clinical pharmacist (National Health Service Band 8c) conducts MR instead of first-level post-foundation clinical pharmacist. Fourteen minutes taken to conduct each MR	£36 135–£75 249 (€44 446–€92 556)	£83 000 (€102 090)	£0.88 (€1.08)	£12.37 (€15.11)	£10 685 (€13 142)	E. £25 450–£64 564 (€31 303–€79 412)	F. 3.38:1–7.04:1
All 116 pADEs were of minimal clinical significance (£6 cost avoidance for each) and undertaken by senior pharmacy technician. Fourteen minutes taken to conduct each MR	£696 (€856)	£35 000 (€43 050)	£0.37 (€0.45)	£4.32 (€5.28)	£3732 (€4591)	G. –£3036 (–€3734) (cost incurred)	H. 0.19:1
All 116 pADEs were significant (non-increased length of stay, £76–£176 cost avoidance for each). First-level post-foundation clinical pharmacist conducts MR. Maximum time (40min) taken to conduct each MR	£8816–£20 416 (€10 844–€25 112)	£51 000 (€62 730)	£0.54 (€0.66)	£21.60 (€26.40)	£18 662 (€22 954)	I. –£9846 (cost incurred) –£1754 (–€12 111–€2157)	J. 0.47:1–1:09:1

MR, medicines reconciliation; pADEs,preventable adverse drug events.

different decisions. Only pharmacy staff salary costs were used to calculate costs incurred, and the perspective was health system only. Wider social, public health and individual costs were not taken into account. However, the modelled costs of a pADE[25] did include a wide perspective. Thus, this is not a full economic evaluation and should not be regarded as such. Approximately 13% of admitted patients had at least one unintended discrepancy detected by MR, which is low compared with the literature,[4 29 30] and the data available did not allow us to calculate the rate of discrepancies per patient. However, this was not an objective of the study. A higher rate of averted pADEs would equate to a larger benefit:cost ratio; therefore, it is possible that our study underestimates the benefits. However, our calculated staff cost of £7.56 per admission MR performed was similar to that of Campbell *et al*.[14] The panel was asked to rate the clinical significance of potential, rather than actual, pADEs. Not all MR discrepancies will lead to an actual pADE; therefore, the pADE rate is likely overestimated. However, there is little published literature describing the conversion rate. Boockvar *et al*.[31] used retrospective record review to detect actual ADEs before and after the introduction of an MR tool to two general medical units of a US Veterans Affairs Medical Center. Actual ADEs due to unintentional admission medication changes (ie, pADEs) occurred in 8.3% of admissions. If the same was true for our patient population, the benefit:cost ratio would be smaller. However, the study authors did not report how ADEs were defined or their clinical significance. Differences in healthcare settings, study methodologies and patient demographics also preclude the application of these findings to our population. pADEs averted by MR were self-reported and not independently validated; therefore, these are subject to bias. The number of MRs observed and timed was relatively small, and the staff observed may have changed their behaviour because they were observed.[32] However, the results were consistent between the different staff. In a study of 30 acute English hospitals,[6] the average time to carry out pharmacy-led MR was 15 min, which compares well with our finding of 14 min. A time-and-motion study of admission and discharge MR in two Canadian Hospitals[13] found much longer times to complete MR; however, in that study, the MR was not pharmacy led. The researchers followed the patients and timed all healthcare professionals, not only pharmacists, involved in MR. Similar numbers of patients to our study, 41 at admission, were included. Our study was observational only and would have had better internal validity if conducted as part of a clinical trial. Finally, generalisability is limited as the selection of staff to be observed was not random, we did not record the observed patients' clinical characteristics or demographics and the work was conducted at a time when EPMA was being implemented in our organisation.

In conclusion, despite some limitations, the results of this study demonstrate the real-world economic value of MR conducted on admission to hospital. There was a cost of £7.56 (€9.30) in pharmacists' time to conduct one MR. Performing MR can prevent the occurrence of pADEs, many of which otherwise would have significant clinical and economic impacts. Using the SCHARR scale, this study calculated the avoided costs associated with one MR to be £34–£80 (€42–€98). The findings also indicate how to ensure pharmacy-led MR is as cost-effective as possible. Further work is urgently required for full economic evaluations of MR in different healthcare settings.

What this paper adds?

What is already known on this subject?

- Pharmacy-led medicines reconciliation (MR) on admission is known to reduce unintended medication discrepancies and to prevent adverse drug events.
- MR is a complex and resource-intensive activity.
- There is a lack of published evidence on the real-life benefit: cost ratio of MR.

What this study adds?

- The economic value of pharmacy-led MR on admission is significant and can be demonstrated by the application of a theoretical costing model to real-life data on potentially preventable adverse drug events (pADEs) averted by MR.
- The economic benefits are significantly reduced if the clinical significance of pADEs is minimal or maximum time is taken to carry out MR.

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Contributors RO conceived the study, analysed data, provided overall supervision and codrafted the original manuscript. SQ supervised data collection, analysed data, codrafted the original manuscript and approved the final version.

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